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Contract Number	**NNX10CD54P**
Title	Reconfigurable, Wideband Radar Transceiver and Antenna for P-band Stretch Processing

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)

There is considerable interest among the earth-science community to pursue P-Band radar development, due to its ability to penetrate deeper into vegetated areas. Measuring biomass is very important for studying the impact of global warming. P-band radar applied for ecological applications can provide the capability of monitoring variations in biomass of forested ecosystems. The proposed P-band radar system design uses the state-of-of-art digital and signal processing technology to reduce the cost, size, and weight of hardware and facilitates reconfigurable operation. The key innovations are:

1. Reconfigurable digital waveform synthesizer and processor using high speed FPGA design.

2. A novel Vivaldi stripline-fed tapered slot antenna for P-band. The key characteristics of this antenna are wide bandwidth operation and high cross-polarization isolation.

3. Digital implementation of P-band receiver, complete with RF sampling, Digital Down-Conversion and Decimation. Further on-board processing like SAR and Digital Beam-former can be supported, depending on the specific mission.

4. Low size, weight and power specifications for the proposed P-band radar and antenna. Our design will employ commercial equivalent of the radiation-hardened Xilinx SIRF (Single-event effects Immune Reconfigurable FPGA). By following design techniques with path to space, future space applications can be supported with minimal redesign.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)

Objective 1: Develop a multi-channel P-band radar transceiver that can synthesize and process the waveforms using direct digital approaches.

Objective 2: Refine the proposed Vivaldi antenna design for array applications and fabricate a single element supporting wideband, dual polarization operation.

Objective 3: Develop fixed-point FPGA firmware for the P-band radar to support waveform synthesis, receiver processing, and RFI sensing / mitigation and high-throughput data interfaces. Resource intensive processing algorithms like SAR and Digital Beam-formers will be partitioned into firmware level development and host processor development.

Objective 4: Develop and test a PC-based radar controlling and signal processing simulator. It will incorporate the SAR processor and be interfaced with the transceiver via high-speed data throughput such as Gigabit Ethernet. A user-friendly GUI will be provided for scientists to specify SAR imaging parameters and input platform information. For the real-time processing situation, processed SAR image will be presented promptly; otherwise, temporarily stored raw data can be processed offline using the same software.

Objective 5: Work closely with NASA to develop a transition plan to integrate with a target airborne platform. Develop ruggedized packaging, mounting concepts for the radar system and pursue commercialization efforts in UHF radar market.

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

Phase-I technical accomplishments are:

- We completed the prototype design of a fully digital P-band transceiver, and demonstrated the capability to synthesize and process wideband/ narrowband P-band waveforms. The waveform modulation can be user specified, like Linear Frequency Modulation (LFM) or Orthogonal Frequency Division Multiplexing (OFDM).

- We designed a Vivaldi antenna also referred to as tapered slot antenna, which is among a few designs that exhibit broadband pattern, broadband impedance and broadband cross polarization isolation. Wide-band dual-polarization pattern can be achieved with two orthogonal Vivaldi antenna elements arranged in array configuration.

- Wideband operation in P-band poses considerable Radio Frequency Interference (RFI) issues as portions of the P-band spectrum is already allocated to others; notably television and government communications. In this Phase-I, we have investigated potential RFI sources in P-band, FCC rules for emitters operating in this band were researched and signal processing approaches for RFI sensing/mitigation we simulated.

- A complete system design for the P-band radar is proposed. We have performed the link budget (SNR and Sigma Naught Analysis) and generated estimates for SWaP for such a system.

NASA Application(s): (Limit 100 words or 1,000 characters, whichever is less)

Biomass mapping
Configured as a conventional side-looking SAR, the proposed system can be used to mapping forest and perform monitoring tasks based on parametric inversion algorithms for polarimetric SAR.

Forest tomography/interforemetry and carbon sequestration
Employing multiple-pass flight plan, the system can also be used to form SAR tomography retrieval of vertical structure of forests. Another example is polarimetric interforemetry which requires two of such radar configured as an InSAR system.

Planetary subsurface sensing and imaging
P-Band SAR for Mars exploration to map the hidden surface of Mars under its thick dust mantle, Ice detection on Moon and Mars.

Non-NASA Commercial Application(s): (Limit 100 words or 1,000 characters, whichever is less)

Forest management
Biomass mapping and forest height estimation can also be used in forest management.

Earth subsurface sensing and imaging
For lightly vegetated or bare soil areas, the low frequency enables our system to penetrate into meters underground. Therefore, it is also a perfect tool for subsurface sensing. Potential applications includes: soil moisture measurement, mineral detection and underground archeological exploration.

FOPEN SAR
FOPEN surveillance is another potential application. The same system can be adapted or used as basis to develop FOPEN radar or SAR which can meet the requirements of military missions.